

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

REC'D 10 OCT 2001

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(PCT Article 36 and Rule 70)

14

Applicant's or agent's file reference 13526Q	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/ISA/416)	
International application No. PCT/FI00/00586	International filing date (day month year) 28.06.2000	Priority date (day month year) 28.06.1999
International Patent Classification (IPC) or national classification and IPC H04N 7/26, H04N 7/34		
Applicant Valtion Teknillinen Tutkimuskeskus et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 05.01.2001	Date of completion of this report 01.10.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88	Authorized officer Jesper Bergstrand /OGU Telephone No. 08-782 25 00

Form PCT/ISA/409 (cover sheet) (January 1998)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/FI00/00586

I. Basis of the report

1. With regard to the elements of the international application:*

- ☒ the international application as originally filed
- ☐ the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the claims:
pages _____, as originally filed
pages _____, as amended (together with any statement) under article 19
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the drawings:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____
- ☐ the sequence listing part of the description:
pages _____, as originally filed
pages _____, filed with the demand
pages _____, filed with the letter of _____

2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language English which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☒ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheet/fig _____

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

** Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/FI00/00586

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

Novelty (N)	Claims	<u>1-5</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-5</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-5</u>	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

Cited documents:

1. CHAUR-HEH HSIEH ET AL "Fast Search Algorithms for Vector Quantization of Images Using Multiple Triangle Inequalities and Wavelet Transform"
2. US 57688629 A (Wise)
3. EP 0964583 A2 (Texas)

The documents cited in the International Search Report represent background art.

The invention defined in claims 1-5 is not disclosed by any of these documents.

None of the cited documents gives any indication towards the claimed method and apparatus for motion estimation, whereby the image blocks included in the search area are arranged in a predetermined order on the basis of the image block average values of the image blocks in question, and whereby a directory memory of an associate memory as well as a partial distance elimination method (for searching a best match) is utilised. No relevant combination of the cited documents would lead a person skilled in the art to the invention defined in the claims.

Therefore, the invention defined in claims 1-5 is novel and is considered to involve an inventive step. It is also considered to be industrially applicable.

RECORD COPY

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PCT REQUEST

13526Q

Original (for SUBMISSION) - printed on 28.06.2000 03:36:12 PM

0 0-1	For receiving Office use only International Application No.	PCT/FI 0 0 / 0 0 5 8 6
0-2	International Filing Date	2 8 JUN 2000 (2 8. 06. 00)
0-3	Name of receiving Office and "PCT International Application"	The Finnish Patent Office PCT International Application
0-4 0-4-1	Form - PCT/RO/101 PCT Request Prepared using	PCT-EASY Version 2.90 (updated 10.05.2000)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	National Board of Patents and Registration (Finland) (RO/FI)
0-7	Applicant's or agent's file reference	13526Q
I	Title of invention	PROCEDURE AND SYSTEM FOR PERFORMING MOTION ESTIMATION
II II-1 II-2 II-4 II-5	Applicant This person is: Applicant for Name Address:	applicant only all designated States except US VALTION TEKNIILLINEN TUTKIMUSKESKUS Vuorimiehentie 5 FIN-02150 Espoo Finland
II-6	State of nationality	FI
II-7	State of residence	FI
III-1 III-1-1 III-1-2 III-1-4 III-1-5	Applicant and/or inventor This person is: Applicant for Name (LAST, First) Address:	applicant and inventor US only VALLI, Seppo c/o VTT Tietotekniikka P.O. Box 1203 FIN-02044 VTT Finland
III-1-6	State of nationality	FI
III-1-7	State of residence	FI

PCT REQUEST

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Original (for SUBMISSION) - printed on 28.06.2000 03:36:12 PM

13526Q

IV-1	Agent or common representative; or address for correspondence The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name	PAPULA OY
IV-1-2	Address:	P.O. Box 981 (Fredrikinkatu 61 A) FIN-00101 HELSINKI Finland
IV-1-3	Telephone No.	+358 9 3480 060
IV-1-4	Facsimile No.	+358 9 3480 0630
IV-1-5	e-mail	papula@papula.fi
V	Designation of States	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW

PCT REQUEST

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10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/SE
10-6	Transmittal of search copy delayed until search fee is paid	

FOR INTERNATIONAL BUREAU USE ONLY

11-1	Date of receipt of the record copy by the International Bureau	25 JULY 2000	(25.07.00)
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MERCHANT & GOULD P.C.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
PROCEDURE AND SYSTEM FOR PERFORMING MOTION ESTIMATION

The specification of which

- a. ☐ is attached hereto
b. ☒ was filed on as application serial no. and was amended on (if applicable) (in the case of a PCT-filed application) described and claimed in international no. PCT/FI00/00586 filed June 28, 2000 and as amended on (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

- a. ☐ no such applications have been filed.
b. ☒ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
Finland	991469	June 28, 1999	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

U.S. PROVISIONAL APPLICATION NUMBER	DATE OF FILING (Day, Month, Year)

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (reprinted below):

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
 - (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.
- (b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and
- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim;
- or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

- (c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:
- (1) Each inventor named in the application;
 - (2) Each attorney or agent who prepares or prosecutes the application; and
 - (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.
- (d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.
- (e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Leonard, Christopher J.	Reg. No. 41,940
Ali, M. Jeffer	Reg. No. 46,359	Lièpa, Marà E.	Reg. No. 40,066
Altera, Allan G.	Reg. No. 40,274	Lindquist, Timothy A.	Reg. No. 40,701
Anderson, Gregg I.	Reg. No. 28,828	Lown, Jean A.	Reg. No. 48,428
Batzli, Brian H.	Reg. No. 32,960	Mayfield, Denise L.	Reg. No. 33,732
Beard, John L.	Reg. No. 27,612	McDonald, Daniel W.	Reg. No. 32,044
Berns, John M.	Reg. No. 43,496	McIntyre, Jr., William F.	Reg. No. 44,921
Branch, John W.	Reg. No. 41,633	Mitchem, M. Todd	Reg. No. 40,731
Brown, Jeffrey C.	Reg. No. 41,643	Mueller, Douglas P.	Reg. No. 30,300
Bruess, Steven C.	Reg. No. 34,130	Nelson, Anna M.	Reg. No. 48,935
Byrne, Linda M.	Reg. No. 32,404	Paley, Kenneth B.	Reg. No. 38,989
Campbell, Keith	Reg. No. 46,597	Parsons, Nancy J.	Reg. No. 40,364
Carlson, Alan G.	Reg. No. 25,959	Pauly, Daniel M.	Reg. No. 40,123
Caspers, Philip P.	Reg. No. 33,227	Phillips, John B.	Reg. No. 37,206
Clifford, John A.	Reg. No. 30,247	Pino, Mark J.	Reg. No. 43,858
Cook, Jeffrey	Reg. No. 48,649	Prendergast, Paul	Reg. No. 46,068
Daignault, Ronald A.	Reg. No. 25,968	Pytel, Melissa J.	Reg. No. 41,512
Daley, Dennis R.	Reg. No. 34,994	Qualey, Terry	Reg. No. 25,148
Daulton, Julie R.	Reg. No. 36,414	Reich, John C.	Reg. No. 37,703
DeVries Smith, Katherine M.	Reg. No. 42,157	Reiland, Earl D.	Reg. No. 25,767
DiPietro, Mark J.	Reg. No. 28,707	Samuels, Lisa A.	Reg. No. 43,080
Doscotch, Matthew A.	Reg. No. P-48,957	Schmaltz, David G.	Reg. No. 39,828
Edell, Robert T.	Reg. No. 20,187	Schuman, Mark D.	Reg. No. 31,197
Epp Ryan, Sandra	Reg. No. 39,667	Schumann, Michael D.	Reg. No. 30,422
Glance, Robert J.	Reg. No. 40,620	Scull, Timothy B.	Reg. No. 42,137
Goff, Jared S.	Reg. No. 44,716	Sebald, Gregory A.	Reg. No. 33,280
Goggin, Matthew J.	Reg. No. 44,125	Skoog, Mark T.	Reg. No. 40,178
Golla, Charles E.	Reg. No. 26,896	Spellman, Steven J.	Reg. No. 45,124
Gorman, Alan G.	Reg. No. 38,472	Stewart, Alan R.	Reg. No. 47,974
Gould, John D.	Reg. No. 18,223	Stoll-DeBell, Kirstin L.	Reg. No. 43,164
Gregson, Richard	Reg. No. 41,804	Sullivan, Timothy	Reg. No. 47,981
Gresens, John J.	Reg. No. 33,112	Sumner, John P.	Reg. No. 29,114
Hamer, Samuel A.	Reg. No. 46,754	Swenson, Erik G.	Reg. No. 45,147
Hamre, Curtis B.	Reg. No. 29,165	Tellekson, David K.	Reg. No. 32,314
Harrison, Kevin C.	Reg. No. 46,759	Trembath, Jon R.	Reg. No. 38,344
Hertzberg, Brett A.	Reg. No. 42,660	Tunheim, Marcia A.	Reg. No. 42,189
Hillson, Randall A.	Reg. No. 31,838	Underhill, Albert L.	Reg. No. 27,403
Holzer, Jr., Richard J.	Reg. No. 42,668	Vandenburgh, J. Derek	Reg. No. 32,179
Hope, Leonard J.	Reg. No. 44,774	Wahl, John R.	Reg. No. 33,044
Jardine, John S.	Reg. No. P-48,835	Weaver, Paul L.	Reg. No. 48,640
Johns, Nicholas P.	Reg. No. 48,995	Welter, Paul A.	Reg. No. 20,890
Johnston, Scott W.	Reg. No. 39,721	Whipps, Brian	Reg. No. 43,261
Kadievitch, Natalie D.	Reg. No. 34,196	Whitaker, John E.	Reg. No. 42,222
Kaseburg, Frederick A.	Reg. No. 47,695	Wier, David D.	Reg. No. P-48,229
Kettelberger, Denise	Reg. No. 33,924	Williams, Douglas J.	Reg. No. 27,054
Keys, Jeramie J.	Reg. No. 42,724	Withers, James D.	Reg. No. 40,376
Knearl, Homer L.	Reg. No. 21,197	Witt, Jonelle	Reg. No. 41,980
Kowalchyk, Alan W.	Reg. No. 31,535	Wong, Thomas S.	Reg. No. 48,577
Kowalchyk, Katherine M.	Reg. No. 36,848	Wu, Tong	Reg. No. 43,361
Lacy, Paul E.	Reg. No. 38,946	Young, Thomas	Reg. No. 25,796
Larson, James A.	Reg. No. 40,443	Zeuli, Anthony R.	Reg. No. 45,255

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould P.C. to the contrary.

I understand that the execution of this document, and the grant of a power of attorney, does not in itself establish an attorney-client relationship between the undersigned and the law firm Merchant & Gould P.C., or any of its attorneys.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below:

Merchant & Gould P.C.
P.O. Box 2903
Minneapolis, MN 55402-0903



I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2 0 1	Full Name Of Inventor	Family Name VALLI	First Given Name Seppo	Second Given Name
	Residence & Citizenship	City Tietotekniikka	State or Foreign Country Finlan	Country of Citizenship Finland
	Mailing Address	Address VTT Tietotekniikka, P.O. Box 1203	City Tietotekniikka	State & Zip Code/Country FIN-02044 VTT, Finland
Signature of Inventor 201:				Date:

**MENETELMÄ JA JÄRJESTELMÄ LIIKE-ESTIMOINNIN
SUORITTAMISEKSI**

KEKSINNÖN ALA

Keksintö liittyy videokuvan kompressointiin.
5 Erityisesti keksintö liittyy uuteen ja kehittyneeseen menetelmään ja järjestelmään liike-estimoinnin suorittamiseksi videokuvan kompressoinnin yhteydessä.

TEKNIIKAN TASO

10 Entuudestaan tunnetaan useita menetelmiä videokuvan kompressoimiseksi. Useimmiten näiden menetelmien eniten aikaa ja laskentatehoa vaativa osa-alue on liike-estimointi. Liike-estimoinnin periaate on seuraavanlainen. Videokuva koostuu aikatasossa peräkkäisistä kuvakehyksistä. Kukin kuvakehys on jaoteltu tietyn kokoisiin kuvalohkoihin. Tyypillisesti kuvalohko
15 on esimerkiksi 8 x 8 kuvapisteen kokoinen. Koodattaessa kuvakehystä esimerkiksi lähetystä varten sitä käsitellään kuvalohko kerrallaan. Kuitenkin sen sijaan, että jokaisen kuvakehksen jokainen kuvalohko lähetettäisiin sellaisenaan, pyritäänkin ensin etsimään edellisestä kuvakehyksestä käsiteltävänä olevan kuvalohkon ympäristöstä, niin sanotulta hakualueelta, joko täysin vastaavaa tai tietyissä rajoissa tarpeeksi lähellä
20 olevaa kuvalohkoa. Mikäli tällainen kuvalohko löytyy, lähetetään kokonaisen lohkoinformaation sijaan vain pelkkä liikevektori, ts. vektori, joka ilmoittaa löydetyn lohkon sijainnin suhteessa alkuperäiseen lohkoon. Lähetettävän informaation määrä vähenee siis
25 huomattavasti.

Eräs toinen videokompressoinnin yhteydessä käytetty menetelmä on vektorikvantisointi. Se eroaa liike-estimoinnista siinä, että koodattavalle lohkolle etsitään vastinetta ennalta määrätystä koodikirjasta
35 sen sijaan, että sitä etsittäisiin edellisestä kuvakehyksestä. Koodikirja on tyypillisesti kokoelma yleis-

simmin esiintyviä kuvalohkoja. Samaa koodikirjaa käytetään luonnollisesti sekä enkooderissa että dekodeerissa.

5 Vaikka liike-estimoinnilla ja vektorikvantisoinnilla saadaan lähetettävän informaation määrää pienennettyä merkittävästi, aiheutuu niistä kuitenkin omat ongelmansa. Tyypillisesti varsinkin etsintävaihe on aikaa vievä. Etsinnän kompleksisuus kasvaa suhteessa hakualueen sivun pituuden neliöön. Tämän vuoksi on
10 pyritty kehittämään erilaisia menetelmiä, joilla etsintää saataisiin nopeutettua. Seuraavissa julkaisuis-
sa on tuotu esiin esimerkkejä menetelmistä, jotka pyrkivät nopeuttamaan liike-estimointia tai vektorikvantisointia joko keskittymällä etsintäalgoritmien tehos-
15 tamiseen tai joillakin muilla keinoin: S. T. Valli, "Very Low Bitrate Coding Using Hierarchical Classified VQ and Cluster Based Segmentation of Motion Information", paper No. 7.3, VLBV94, University of Essex, UK, April 1994; H. Li, A. Lundmark, R. Forchheimer, "Image
20 Sequence Coding at Very Low Bitrates: A Review", IEEE Transactions on Image Processing, Vol.3, No.5, September 1994; H. Abut, ed., "Vector Quantization", IEEE Press, 1990; G. Poggi, "Fast Algorithm for Full-Search VQ Encoding", Electronic Letters, Vol.29, No.123, June
25 1993; C.-M. Huang, Q. Bi, G. S. Stiles, R. W. Harris, "Fast Full Search Equivalent Encoding Algorithms for Image Compression Using Vector Quantization", IEEE Transactions on Image Processing, Vol.1, No.3, July 1992.

30 Nykyisillä menetelmillä hakualue on maksimissaan tyypillisesti ± 15 kuvapistettä koodattavan lohkon origosta. Jo tällöinkin etsintä on niin kompleksista, ettei sen suorittaminen ohjelmallisesti ole yleensä enää mahdollista, vaan joudutaan käyttämään
35 kalliita laitteistopohjaisia ratkaisuja, kuten erityisiä signaalinkäsittelypiirejä. Kuitenkin erilaisten alhaisen siirtonopeuden/alhaisen kuvataajuuden sovel-

lusten yhteydessä mainittua ± 15 kuvapistettä suurem-
matkin siirtymät ovat yleisiä liikkeen aikana. Tarvet-
ta nykyistä tehokkaammille menetelmille siis on.

5 Esillä olevan keksinnön tarkoituksena on tuo-
da esiin uudenlainen menetelmä ja järjestelmä, joka
poistaa edellä mainitut epäkohdat. Erityisesti tarkoi-
tuksena on tuoda esiin menetelmä ja järjestelmä, joka
mahdollistaa liike-estimoinnin suorittamisen ohjelmal-
lisesti tavallisessa PC-ympäristössä, ja kuitenkin sa-
10 manaikaisesti aiempaa tehokkaammin.

KEKSINNÖN YHTEENVETO

Esillä olevan keksinnön mukainen menetelmä
liike-estimoinnin suorittamiseksi videokuvan kompres-
15 soinnissa käsittää seuraavat vaiheet. Kuvakehyksestä N
määritetään kuvalohko, joka halutaan koodata. Mainit-
tua kuvakehystä N edeltävästä kuvakehyksestä N-1 mää-
ritetään kyseisen kuvalohkon sijaintia vastaava liike-
vektoreiden hakualue. Kuvalohkokeskiarvot määritetään
20 kaikissa mahdollisissa mainitun hakualueen sisältämis-
sä kuvalohkojen sijaintikohdissa ennalta määrätyn suu-
ruisella siirtymällä. Tämän jälkeen järjestetään ky-
seisen hakualueen sisältämät kuvalohkot kyseisten ku-
valohkojen kuvalohkokeskiarvojen perusteella ennalta
25 määrättyyn järjestykseen. Entuudestaan tunnettua on
suorittaa edellä mainittu järjestely käyttäen apuna
erilaisia järjestelyalgoritmeja (sorting algorithm).
Kyseisten algoritmien haittana on kuitenkin niiden hi-
taus. Seuraavaksi etsitään kyseisen hakualueen kuva-
30 lohkoista vaihtoehto, joka parhaiten vastaa koodatta-
vana olevaa kuvalohkoa. Paras vastaavuus voidaan mää-
rittää esimerkiksi minimivirheen avulla, ts. lohkot,
joiden välinen virhe on pienin, vastaavat parhaiten
toisiaan.

35 Kuvalohkokeskiarvojen määrittämisellä tarkoi-
tetaan tässä yhteydessä sitä, että edullisesti haetaan
jo edellisiä kuvalohkoja koodattaessa lasketut ja tal-

lennetut kuvalohkokeskiarvot erityisestä kuvalohkokeskiarvomuistista. Tämä on mahdollista siksi, että koodattavalle kuvalohkolle määritetty hakualue on tyypillisesti osittain sama kuin edellisiä koodattuja kuvalohkoja vastanneet hakualueet, joilla kuvalohkokeskiarvojen määrittäminen ja tallennus kyseiseen muistiin on jo tapahtunut. Jos kuitenkin liikeestimointia ei ole käytetty edellisiä kuvalohkoja koodattaessa, tai jos kuvalohkokeskiarvoa ei muusta syystä löydy valmiina mainitusta muistista, kuvalohkokeskiarvo lasketaan ja tallennetaan kyseiseen muistiin.

Edellä kuvatussa edullisessa menettelyssä kuvakehyksen N-1 kuvalohkokeskiarvoja lasketaan ja tallennetaan sitä mukaa kun kuvakehyksen N kuvalohkoja koodataan. Kuvalohkokeskiarvot voidaan kuitenkin laskea ja tallentaa myös kerralla ennen kuvalohkojen koodausta. Tämä ei ole kuitenkaan yleensä edullista siksi, että kuvalohkokeskiarvojen laskentaa edellyttävää liikeestimointia ei välttämättä suoriteta kaikkia kuvalohkoja koodattaessa.

Keksinnön mukaisesti hakualueen sisältämät kuvalohkot järjestetään tallentamalla kyseisten kuvalohkojen kuvalohkokeskiarvot assosiatiivisen muistivälineen hakemistomuistin muistipaikkoihin nousevaan tai laskevaan järjestykseen, sekä tallentamalla hakemistomuistin kutakin muistipaikkaa vastaavaan antomuistin muistipaikkaan niiden kuvalohkojen sijaintitiedot, joiden kuvalohkokeskiarvo vastaa kyseiseen hakemistomuistin muistipaikkaan tallennettua arvoa. Mainitun assosiatiivisen muistivälineen avainsanana käytetään koodattavan kuvalohkon kuvalohkokeskiarvoa.

Assosiatiivisella muistivälineellä tarkoitetaan tässä digitaalista muistivälinettä, kuten esimerkiksi muistipiiriä, jossa normaali osoitteendekoodauslogiikka on korvattu erityisellä hakemistomuistilla (directory memory). Hakemistomuisti koostuu muistipaikoista, joihin kuhunkin on tallennettu esimerkiksi

tietty merkkijono. Lisäksi assosiatiiviseen muistivä-
 lineeseen kuuluu antomuisti (output memory), jonka
 muistipaikkoihin varsinainen data on tyypillisesti
 tallennettu. Kukin antomuistin muistipaikka on assosi-
 5 oitu yhden tai useamman hakemistomuistin muistipaikan
 kanssa. Muistille annetaan syötteenä tietty avainsana
 (key word), joka on esimerkiksi merkkijono. Jos hake-
 mistomuistin jostakin muistipaikasta löytyy vastine
 (matching tag) avainsanalle, saadaan tulosteena kysei-
 10 sen hakemistomuistin muistipaikkaa vastaavan antomuis-
 tin muistipaikan sisältö. Esimerkki assosiatiivisesta
 muistivälineestä on CAM-muisti (Content Addressable
 Memory, CAM). Assosiatiivista muistivälinettä on esi-
 telty tarkemmin esimerkiksi julkaisussa T. Kohonen,
 15 "Self-Organization and Associative Memory", Springer-
 Verlag, 1984.

Edelleen keksinnön mukaisesti käsiteltävien
 kuvalohkojen joukkoa rajoitetaan keskimääräisen vir-
 heen perusteella seuraavan yhtälön mukaisesti:

20 $Y_A = \{y_i : |\xi_x - \xi_i| \leq D_{\min}\}$, jossa
 Y_A on käsiteltävien kuvalohkojen rajoitettu
 joukko,
 y_i on kuvalohkoehdokas i ,
 ξ_x on koodattavan kuvalohkon kuvalohkokes-
 25 kiarvo,
 ξ_i on kuvalohkoehdokkaan i kuvalohkokeskiar-
 vo, ja

D_{\min} on parhaan kuvalohkoehdokkaan virhe kuva-
 pistettä kohti.

30 D_{\min} voidaan laskea esimerkiksi RMS-virheenä
 tai MAD-virheenä (Root-Mean-Squared, RMS; Mean-
 Absolute-Distortion, MAD). Rajoittamista keskimääräi-
 sen virheen perusteella on tarkasteltu yksityiskohtai-
 semmin esimerkiksi edellä mainituissa julkaisuissa C.-
 35 M. Huang, Q. Bi, G. S. Stiles, R. W. Harris, "Fast
 Full Search Equivalent Encoding Algorithms for Image
 Compression Using Vector Quantization", IEEE Transac-

tions on Image Processing, Vol.1, No.3, July 1992 sekä G. Poggi, "Fast Algorithm for Full-Search VQ Encoding", Electronic Letters, Vol.29, No.123, June 1993.

Edelleen keksinnön mukaisesti kyseiseen rajoitettuun joukkoon kuuluvista kuvalohkoista etsitään paras vaihtoehto PDE-menetelmää (Partial Distance Elimination, PDE) käyttämällä. PDE-menetelmä on sinänsä tunnettu menetelmä, jota käytetään esimerkiksi vektorikvantisoinnissa etsinnän nopeuttamiseen. Virhe koodattavan kuvalohkon ja kunkin kuvalohkoehdokkaan välillä lasketaan normaalisti kuvapiste kuvapisteeltä. Jos virhe ylittää siihenastisen minimivirheen, laskenta lopetetaan ja siirrytään suorittamaan vertailua seuraavaan kuvalohkoehdokkaaseen.

Keksinnön eräässä sovelluksessa hakualueena käytetään ennalta määrättyä säännöllisen muotoista aluetta koodattavan kuvalohkon ympäriltä. Tyypillisesti hakualue on esimerkiksi nelikulmion muotoinen.

Keksinnön eräässä sovelluksessa määritetään alue, joka muodostuu yhden tai useamman peräkkäisten kuvakehysten välillä nopeasti liikkuvan kohteen käsittämästä alueesta, ja käytetään mainittua aluetta hakualueena.

Keksinnön eräässä sovelluksessa kuvalohkojen mahdolliset sijaintikohdat määritetään yhden kuvapisteen, kuvapisteen puolikkaan tai muun murto-osan siirtymällä.

Esillä olevan keksinnön etuna tunnettuun tekniikkaan verrattuna on, että se nopeuttaa liikeestimointia huomattavasti, ja siten mahdollistaa liikeestimoinnin suorittamisen ohjelmallisesti tavallisessa PC-ympäristössä, ja kuitenkin samanaikaisesti aiempaa tehokkaammin. Koska liike-estimointi voidaan suorittaa ohjelmallisesti, kalliita laitepohjaisia ratkaisuja ei tarvita, ja siten keksinnön myötä liikeestimointi muuttuu myös aiempaa edullisemmaksi.

KUVALUETTELO

Seuraavassa keksintöä selostetaan oheisten sovellusesimerkkien avulla viittaamalla oheiseen piirustukseen, jossa

- 5 kuviossa 1 on lohkokaaviomaisesti kuvattu eräs keksinnön mukainen järjestelmä.

KEKSINNÖN YKSITYISKOHTAINEN SELOSTUS

- 10 Kuviossa 1 on kuvattu erään keksinnön mukaisen järjestelmän komponentit. Järjestelmä on toteutettu esimerkiksi ohjelmallisina komponentteina tavalliseen PC-tietokoneeseen. Järjestelmään kuuluu määrittelyvälineet 1, joilla määritetään kuvalohkokeskiarvot koodattavan kuvalohkon sijaintia vastaavan hakualueen
15 sisältämissä kuvalohkojen sijaintikohdissa, järjestelyvälineet 2, joilla järjestetään kuvalohkot niiden kuvalohkokeskiarvojen perusteella ja etsintävälineet 3, joilla etsitään kuvalohkoista vaihtoehto, joka parhaiten vastaa koodattavana olevaa kuvalohkoa. Määrittelyvälineet 1 käsittävät kuvalohkokeskiarvomuistin (ei esitetty), johon lasketut kuvalohkokeskiarvot tallennetaan, ja josta niitä tarvittaessa haetaan. Käytännössä kuvalohkokeskiarvomuisti voi olla esimerkiksi tietty osa PC-tietokoneen muistiavaruutta.

- 25 Keksinnön mukaisesti järjestelmään kuuluu CAM-muisti 2, jonka avulla kuvalohkot järjestetään tallentamalla niiden kuvalohkokeskiarvot hakemistomuistin muistipaikkoihin nousevaan tai laskevaan järjestykseen ja tallentamalla hakemistomuistin kutakin
30 muistipaikkaa vastaavaan antomuistin muistipaikkaan niiden kuvalohkojen sijaintitiedot, joiden kuvalohkokeskiarvo vastaa kyseiseen hakemistomuistin muistipaikkaan talletettua arvoa. Käytännössä CAM-muisti 2 on edullisesti tietty osa PC-tietokoneen muistiavaruutta, mutta se voi olla myös esimerkiksi erillinen
35 muistipiiri. Edelleen keksinnön mukaisesti järjestel-

mään kuuluu välineet 3, joilla rajoitetaan käsiteltävien kuvalohkojen joukkoa keskimääräisen virheen perusteella, ja välineet 3, joilla etsitään kyseiseen rajoitettuun joukkoon kuuluvista kuvalohkoista paras vaihtoehto PDE-menetelmää käyttämällä.

Kuvakehyksestä N määritetään kuvalohko, joka halutaan koodata. Mainittua kuvakehystä N edeltävästä kuvakehyksestä N-1 määritetään kyseisen kuvalohkon sijaintia vastaava liikevektoreiden hakualue. Kuvalohkokeskiarvot määritetään kaikissa mahdollisissa mainitun hakualueen sisältämissä kuvalohkojen sijaintikohdissa ennalta määrätyn suuruisella siirtymällä, kuten esimerkiksi yhden kuvapisteen, kuvapisteen puolikkaan tai muun murto-osan siirtymällä. Tämän jälkeen järjestetään kyseiset kuvalohkot ennalta määrättyyn järjestykseen niiden kuvalohkokeskiarvojen perusteella, sekä etsitään kyseisen hakualueen kuvalohkoista vaihtoehto, joka parhaiten vastaa koodattavana olevaa kuvalohkoa. Paras vastaavuus voidaan määrittää esimerkiksi minimivirheen avulla, ts. lohkot, joiden välinen virhe on pienin, vastaavat parhaiten toisiaan.

Käytännössä kuvalohkokeskiarvojen määrittäminen tapahtuu edullisesti hakemalla jo edellisiä kuvalohkoja koodattaessa lasketut ja tallennetut kuvalohkokeskiarvot erityisestä kuvalohkokeskiarvomuistista. Tämä on mahdollista siksi, että koodattavalle kuvalohkolle määritetty hakualue on tyypillisesti osittain sama kuin edellisiä koodattuja kuvalohkoja vastaan neet hakualueet, joilla kuvalohkokeskiarvojen määrittäminen ja tallennus kyseiseen muistiin on jo tapahtunut. Jos liike-estimointia ei kuitenkaan ole käytetty edellisiä kuvalohkoja koodattaessa, tai jos kuvalohkokeskiarvoa ei muusta syystä löydy valmiina mainitusta muistista, kuvalohkokeskiarvo lasketaan ja tallennetaan kyseiseen muistiin.

Edellä kuvatussa edullisessa menettelyssä kuvakehyksen N-1 kuvalohkokeskiarvoja lasketaan ja tal-

lennetaan sitä mukaa kun kuvakehyksen N kuvalohkoja koodataan. Kuvalohkokeskiarvot voidaan kuitenkin laskea ja tallentaa myös kerralla ennen kuvalohkojen koodausta. Tämä ei ole kuitenkaan yleensä edullista siksi, että kuvalohkokeskiarvojen laskentaa edellyttävää liike-estimointia ei välttämättä suoriteta kaikkia kuvalohkoja koodattaessa.

Keksinnön mukaisesti kuvalohkot järjestetään tallentamalla niiden kuvalohkokeskiarvot CAM-muistin 2 hakemistomuistin muistipaikkoihin nousevaan tai laskevaan järjestykseen. Edelleen hakemistomuistin kutakin muistipaikkaa vastaavaan antomuistin muistipaikkaan tallennetaan niiden kuvalohkojen sijaintitiedot, joiden kuvalohkokeskiarvo vastaa kyseiseen hakemistomuistin muistipaikkaan talletettua arvoa. CAM-muistin 2 avainsanana käytetään koodattavan kuvalohkon kuvalohkokeskiarvoa.

Hakualueena käytetään ennalta määrättyä säännöllisen muotoista aluetta koodattavan kuvalohkon ympäriltä. Hakualue on esimerkiksi nelikulmion muotoinen. Vaihtoehtoisesti hakualue voi olla myös alue, joka muodostuu yhden tai useamman peräkkäisten kuvakehysten välillä nopeasti liikkuvan objektin käsittämistä alueesta.

Keksintöä ei rajata pelkästään edellä esitetyistä sovellusesimerkkejä koskevaksi, vaan monet muunnokset ovat mahdollisia pysyttäessä patenttivaatimuk-sien määrittelemän keksinnöllisen ajatuksen puitteis-sa. Eräs tällainen muunnos on kuvatun keksinnön käyt-täminen toisiaan vastaavien kuvalohkojen etsimiseen stereokuvaparin (vasemman- ja oikeanpuoleisten) kuvien välillä. Tätä liike-estimoinnille läheistä menettelyä on kuvattu esimerkiksi julkaisussa I. Dinstein et al., "On the Compression of Stereo Images: Preliminary Re-sults", Signal Processing 17 (1989), s. 373-382.

PATENTTIVAATIMUKSET

1. Menetelmä liike-estimoinnin suorittamiseksi videokuvan kompressoinnissa, joka menetelmä käsittää seuraavat vaiheet:

5 määritetään koodattava kuvalohko kuvakehyksestä N,

 määritetään kyseisen kuvalohkon sijaintia vastaava hakualue kuvakehyksestä N-1,

10 määritetään kuvalohkokeskiarvot kyseisen hakualueen sisältämissä kuvalohkojen sijaintikohdissa ennalta määrätyn suuruisella siirtymällä,

 järjestetään kyseisen hakualueen sisältämät kuvalohkot kyseisten kuvalohkojen kuvalohkokeskiarvojen perusteella ennalta määrättyyn järjestykseen, ja

15 etsitään kyseisen hakualueen kuvalohkoista vaihtoehto, joka parhaiten vastaa koodattavana olevaa kuvalohkoa, t u n n e t t u siitä, että menetelmä edelleen käsittää vaiheet:

 järjestetään hakualueen sisältämät kuvalohkot
20 tallentamalla kyseisten kuvalohkojen kuvalohkokeskiarvot assosiatiivisen muistivälineen hakemistomuistin muistipaikkoihin nousevaan tai laskevaan järjestykseen, sekä tallentamalla hakemistomuistin kutakin muistipaikkaa vastaavaan antomuistin muistipaikkaan
25 niiden kuvalohkojen sijaintitiedot, joiden kuvalohkokeskiarvo vastaa kyseiseen hakemistomuistin muistipaikkaan talletettua arvoa,

 käytetään kyseisen assosiatiivisen muistivälineen avainsanana koodattavan kuvalohkon kuvalohkokeskiarvoa,
30

 rajoitetaan käsiteltävien kuvalohkojen joukkoa keskimääräisen virheen perusteella, ja

 etsitään kyseiseen rajoitettuun joukkoon kuuluvista kuvalohkoista paras vaihtoehto PDE-menetelmää
35 käyttämällä.

2. Patenttivaatimuksen 1 mukainen menetelmä, tunnettu siitä, että menetelmä edelleen käsittää vaiheen:

5 käytetään hakualueena ennalta määrättyä säännöllisen muotoista aluetta koodattavan kuvalohkon ympäriltä.

3. Patenttivaatimuksen 1 mukainen menetelmä, tunnettu siitä, että menetelmä edelleen käsittää vaiheet:

10 määritetään alue, joka muodostuu yhden tai useamman peräkkäisten kuvakehysten välillä nopeasti liikkuvan kohteen käsittämästä alueesta, ja

käytetään mainittua aluetta hakualueena.

4. Jonkin patenttivaatimuksista 1 - 3 mukainen menetelmä, tunnettu siitä, että menetelmä edelleen käsittää vaiheen:

määritetään kuvalohkojen mahdolliset sijain-
tikohdat yhden kuvapisteen, kuvapisteen puolikkaan tai
muun murto-osan siirtymällä.

20 5. Järjestelmä liike-estimoinnin suorittamiseksi videokuvan kompressoinnissa, joka järjestelmä käsittää:

määrittelyvälineet (1), joilla määritetään kuvalohkokeskiarvot koodattavan kuvalohkon sijaintia
25 vastaavan hakualueen sisältämissä kuvalohkojen sijaintikohdissa ennalta määrätyn suuruisella siirtymällä kyseisen koodattavan kuvalohkon sisältävää kuvakehystä edeltävästä kuvakehyksestä,

järjestelyvälineet (2), joilla järjestetään
30 kuvalohkot kyseisten kuvalohkojen kuvalohkokeskiarvojen perusteella, ja

etsintävälineet (3), joilla etsitään kuvalohkoista vaihtoehto, joka parhaiten vastaa koodattavana olevaa kuvalohkoa, tunnettu siitä, että järjestelmä edelleen käsittää:

35 assosiatiivisen muistivälineen (2), jolla järjestetään hakualueen sisältämät kuvalohkot tallen-

tamalla kyseisten kuvalohkojen kuvalohkokeskiarvot kyseisen assosiatiivisen muistivälineen (2) hakemistomuistin muistipaikkoihin nousevaan tai laskevaan järjestykseen, sekä tallentamalla kyseisen hakemistomuistin kutakin muistipaikkaa vastaavaan antomuistin muistipaikkaan niiden kuvalohkojen sijaintitiedot, joiden kuvalohkokeskiarvo vastaa kyseiseen hakemistomuistin muistipaikkaan talletettua arvoa, ja jonka assosiatiivisen muistivälineen (2) avainsanana käytetään koodattavan kuvalohkon kuvalohkokeskiarvoa,

välineet (3), joilla rajoitetaan käsiteltävien kuvalohkojen joukkoa keskimääräisen virheen perusteella, ja

välineet (3), joilla etsitään kyseiseen rajoitettuun joukkoon kuuluvista kuvalohkoista paras vaihtoehto PDE-menetelmää käyttämällä.

(57) TIIVISTELMÄ

Esillä olevan keksinnön kohteena on menetelmä ja järjestelmä liike-estimoinnin suorittamiseksi videokuvan kompressoinnissa. Keksinnön mukaisesti liike-estimoinnissa käytetään apuna assosiatiivista muistivälinettä, sekä rajoitetaan käsiteltävien kuvalohkojen joukkoa keskimääräisen virheen perusteella ja etsitään kuvalohkoista paras vaihtoehto PDE-menetelmän avulla. Keksinnön ansiosta liike-estimointi voidaan suorittaa ohjelmallisesti tavallisessa PC-ympäristössä, ja kuitenkin samanaisesta aiempaa tehokkaammin.

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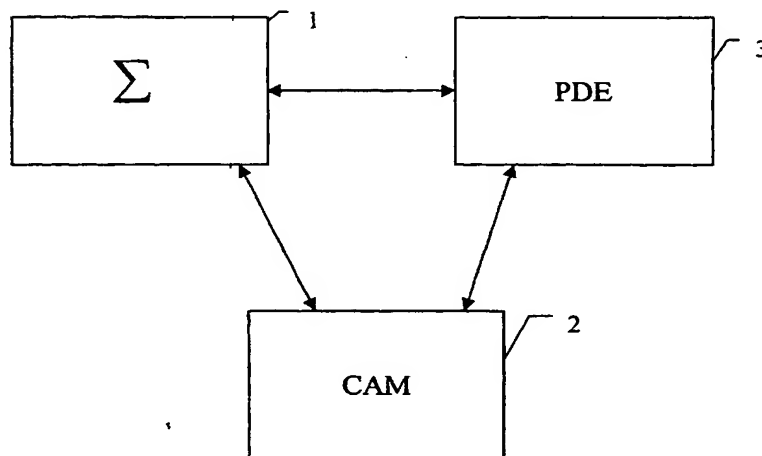
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(54) Title: PROCEDURE AND SYSTEM FOR PERFORMING MOTION ESTIMATION



(57) Abstract: The present invention relates to a method and system for performing motion estimation in video image compression. In accordance with the invention, an associative memory device is used in motion estimation, and the group of the image blocks to be processed is restricted on the basis of a mean error and the best match is searched among the image blocks using the PDE method. Thanks to the invention, motion estimation may be performed via software in a regular PC environment and still more efficiently than before.



WO 01/01692 A1

PROCEDURE AND SYSTEM FOR PERFORMING MOTION ESTIMATION
FIELD OF THE INVENTION

The invention relates to video image compression. In particular, the invention relates to a new
5 and advanced method and system of performing motion estimation in conjunction with video image compression.

PRIOR ART

10 Previously known are several methods of video image compression. For most of the methods, motion estimation is the stage demanding the most time and computing efficiency. The main principal of motion estimation is as follows. A video image consists of successive frames in a time level. Each frame is divided
15 into image blocks of certain size. Typically a block is, e.g. the size of eight by eight pixels. When coding a frame, e.g. for transmission it is being processed block by block. However, instead of transmitting each block of each frame as such, an attempt is made
20 to search from the previous frame, in the area of the image block being worked, in so called search area, a block either exactly matching with or in a certain scope close to the current block. In case this kind of image block is found, just the motion vector, i.e.
25 vector denoting the location of the found block in relation to the original one is transmitted instead of transmitting the whole block of information. The amount of the information to be sent is thereby remarkably reducing.
30

One other method used in conjunction with video compression is vector quantization. It differs from motion estimation in that the matching tag for the block to be coded is searched from a predetermined
35 code book, instead of searching it from the previous frame. The code book is typically a group of most com-

monly appearing image blocks. The same code book is naturally used both for the encoders and decoders.

Although using motion estimation and vector quantization remarkably helps to reduce the amount of the information to be transmitted, there are, however, certain problems associated with them. Typically, especially the search phase is time-consuming. The complexity of search increases in relation to the square of the page length of the search area. Therefore, attempts have been made to develop different methods using which the search may be made faster. The following publications disclose examples of methods with the intent to fasten motion estimation and vector quantization either by focusing on enhancing the search algorithms or using some other means: S. T. Valli, "Very Low Bitrate Coding Using Hierarchical Classified VQ and Cluster Based Segmentation of Motion Information", paper No. 7.3, VLBV94, University of Essex, UK, April 1994; H. Li, A. Lundmark, R. Forchheimer, "Image Sequence Coding at Very Low Bitrates: A Review", IEEE Transactions on Image Processing, Vol.3, No.5, September 1994; H. Abut, ed., "Vector Quantization", IEEE Press, 1990; G. Poggi, "Fast Algorithm for Full-Search VQ Encoding", Electronic Letters, Vol.29, No.123, June 1993; C.-M. Huang, Q. Bi, G. S. Stiles, R. W. Harris, "Fast Full Search Equivalent Encoding Algorithms for Image Compression Using Vector Quantization", IEEE Transactions on Image Processing, Vol.1, No.3, July 1992.

When using the present methods the search area is at maximum typically ± 15 pixels of the point of origin of the block to be coded. And even in that case the search is so complex that carrying out it via software is generally speaking not even possible, instead expensive device-based solutions have to be used, such as specific signal processing circuits. However, shifts even bigger than the ± 15 pixels men-

tioned in conjunction with the applications of low transfer rate/low image frequency are common during the motion. Thus, there is a need for more efficient methods.

5 The objective of the present invention is to disclose a method and system that would eliminate the drawbacks mentioned above. One specific objective of the invention is to disclose a method and system that makes it possible to perform motion estimation in a
10 regular PC environment and at the same time more efficiently than before.

SUMMARY OF THE INVENTION

 The method of the present invention for performing motion estimation in video image compression
15 comprises the following stages. On frame N, an image block that is wished to be coded is determined. On frame N-1 prior to the aforementioned frame N, a search area of motion vectors corresponding to the location of the block in question is determined. The
20 image block average values are determined in every possible location area of the image blocks included in the aforementioned search area using a shift of predetermined size. After this, based on the image block
25 average values of the image blocks, the image blocks included in the aforementioned search area are arranged in a predetermined order. Previously known is a method of performing the aforementioned arrangement by using different sorting algorithms. The disadvantage
30 associated with the algorithms in question is, however, their slowness. Next, an alternative best matching with the image block to be coded is searched among the image blocks of the search area in question. The maximum correspondence may be determined, e.g. using a
35 minimum error, i.e. the blocks with the smallest error between them are best matching with each other.

The determining of the image block average values is used herein to mean that in a preferred case, the image block average values computed and stored already in connection with the coding of the previous image blocks are retrieved from a specific image block average value memory. This is possible because the search area determined for the image block to be coded is typically partly the same as the search area corresponding to the previous coded image blocks for which the determining of image block average values and storing in the memory in question has already happened. If however, motion estimation is not used in coding the previous image blocks or if the image block average value cannot be found in the aforementioned memory, so the image block average value is computed and stored in the memory in question.

In the advantageous procedure presented above the image block average values of frame N-1 are computed and stored as the image blocks of frame N are being coded. The image block average values may, however, be computed and stored in one go before coding the image blocks. This is, however, not preferable because motion estimation requiring computing of the image block average values is not necessarily performed in coding every image block.

In accordance with the invention, the image blocks included in the search area are sorted by storing the image block average values of the image blocks in question in the memory locations of the directory memory of an associative memory device in an ascending or descending order and by storing in the memory location of the output memory corresponding to each memory location of the directory memory the location data of the image blocks whose image block average value corresponds to the value stored in the memory location of the directory memory in question. As a key word of the aforementioned associative memory device, the image

block average value of the image block to be coded is used.

An associative memory device is used herein to mean a digital memory device, such as, e.g. a memory chip in which the regular address coding logic has been substituted with a specific directory memory. The directory memory consists of memory locations with, e.g. a certain character string stored in each one of them. In addition, the associative memory device includes output memory in the memory locations of which the actual data is typically stored. Each one of the memory locations of the output memory is associated with one or more memory locations of the directory memory. A certain key word, which might be, e.g. a character string, is given to the memory to serve as an input. In case a matching tag with the key word is found in some memory location of the directory memory, as output is received the content of the memory location of the output memory corresponding to the memory location of the directory memory in question. An example of an associative memory device is CAM (Content Addressable Memory, CAM). A more detailed description of an associative memory device can be found, e.g. in the publication T. Kohonen, "Self-Organization and Associative Memory", Springer-Verlag, 1984.

Further in accordance with the invention, the group of the image blocks to be processed is restricted on the basis of a mean error in accordance with the following equation:

$$Y_A = \{y_i : |\xi_x - \xi_i| \leq D_{\min}\}, \text{ in which}$$

Y_A represents the restricted group of the image blocks to be processed,

y_i is the candidate block i ,

ξ_x is the image block average value of the image block to be coded.

ξ_i is the image block average value of the candidate block i , and

D_{min} is the error of the best candidate block per each pixel.

D_{min} may be computed, e.g. as an RMS error or
5 as a MAD error (Root-Mean-Squared, RMS; Mean-Absolute-Distortion, MAD). A more detailed description of restriction on the basis of mean error can be found, e.g. in the aforementioned publications C.-M. Huang, Q. Bi, G. S. Stiles, R. W. Harris, "Fast Full Search
10 Equivalent Encoding Algorithms for Image Compression Using Vector Quantization", IEEE Transactions on Image Processing, Vol.1, No.3, July 1992 and G. Poggi, "Fast Algorithm for Full-Search VQ Encoding", Electronic Letters, Vol.29, No.123, June 1993.

15 Furthermore in accordance with the invention, the best match is searched among the blocks included in the restricted group of images in question by using the PDE method (Partial Distance Elimination, PDE). PDE is a method known in itself, which is used, e.g.
20 in vector quantization for fastening the search. The error between the image block to be coded and the candidate block is computed normally pixel by pixel. If the error exceeds the minimum error up to that stage, the computing is stopped and the comparison is done in
25 the next candidate block.

In an embodiment of the invention, a predetermined area of regular shape around the image block to be coded is used as search area. The search area is typically, e.g. the shape of a quadrangle.

30 In an embodiment of the invention, an area is defined that is comprised of an area of one or more objects moving fast between successive image frames, and the said area is used as search area.

In an embodiment of the invention, the possible location areas are defined by using a shift of one
35 pixel, a half of a pixel or some other fractional shift.

The advantage of the present invention when compared with the prior art is that it remarkably fastens motion estimation and thereby makes it possible to perform motion estimation via software in a regular PC environment and still more efficiently than before. Since motion estimation may be performed via software, there is no need for expensive device-based solutions, and therefore, by the aid of the invention, motion estimation may be made more advantageous than before.

LIST OF FIGURES

In the following section, the invention is described by way of examples of its embodiments with reference to the attached drawing, wherein

Fig. 1 represents a system of the invention described in a block diagram.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 represents the components of a system of the invention. The system has been implemented, e.g. in a form of programmable components in a regular PC device. The system comprises means of determining 1 using which the image block average values are determined in the location areas of the image blocks included in the search area corresponding to the location of the image block to be coded, means of sorting 2 using which the image blocks are sorted on the basis of their image block average values, and means of searching 3 using which an alternative best matching with the image block to be coded is searched among the image blocks. The means of determining 1 comprise an image block average value memory (not presented), wherein the computed image block average values are stored and where they are retrieved from in case needed. In practice, the image block average value

memory may be, e.g. a certain part of the memory space of a PC device.

In accordance with the invention, the system comprises a CAM memory 2 by means of which the image blocks are sorted by storing their image block average values in the memory locations of the directory memory in an ascending or descending order and by storing in the memory location of the output memory corresponding to each memory location of the directory memory the location data of the image blocks whose image block average value corresponds to the value stored in the memory location of the directory memory in question. In practice, the CAM memory 2 is advantageously a certain part of the memory space of a PC device, but it may be, e.g. a separate memory chip. Further in accordance with the invention, the system comprises means 3 for restricting the group of the image blocks to be coded on the basis of a mean error, and means 3 for searching among the image blocks included in the restricted group of images the best match by using the PDE method.

On frame N, an image block that is wished to be coded is determined. On frame N-1 prior to the aforementioned frame N, a search area of motion vectors corresponding to the location of the block in question is determined. The image block average values are determined in every possible location area of the image blocks included in the aforementioned search area using a shift of predetermined size, such as a shift of one pixel, a half of a pixel or some other fractional shift. After this, the image blocks in question are arranged in a predetermined order on the basis of their image block average values and an alternative best matching with the image block to be coded is searched among the image blocks of the search area in question. The maximum correspondence may be determined, e.g. using a minimum error, i.e. the

blocks with the smallest error between them are best matching with each other.

In practice, the determining of image block average values happens by retrieving the image block average values computed and stored already in connection with the coding of the previous image blocks from a specific image block average value memory. This is possible because the search area determined for the image block to be coded is typically partly the same as the search area corresponding to the previous coded image blocks for which the determining of image block average values and storing in the memory in question has already happened. If however, motion estimation is not used in coding the previous image blocks or if the image block average value cannot be found in the aforementioned memory for some reason or other, so the image block average value is computed and stored in the memory in question.

In the advantageous procedure presented above the image block average values of frame N-1 are computed and stored as the image blocks of frame N are being coded. The image block average values may, however, be computed and stored in one go before coding the image blocks. This is, however, not preferable because motion estimation requiring computing of the image block average values is not necessarily performed in coding every image block.

In accordance with the invention, the image blocks are sorted by storing their image block average values in the memory locations of the directory memory of the CAM memory 2 in an ascending or descending order. Further, the location data of the image blocks whose image block average value corresponds to the value stored in the memory location of the directory memory in question is stored in the memory location of the output memory corresponding to each memory location of the directory memory. As a key word of the CAM

memory 2, the image block average value of the image block to be coded is used. As search area, a predetermined area of regular shape around the image block to be coded is used. The search area is, e.g. the shape of a quadrangle. Alternatively, the search area may be an area comprised of an area formed by one or more objects moving fast between successive frames.

The invention is not restricted to the examples of its embodiments presented above, instead many variations are possible within the scope of the inventive idea defined by the claims. One such variation is the using of the present invention for the searching of matching image blocks between the images of a pair of stereo images (the left-hand and right-hand image). This procedure similar to motion estimation is described, e.g. in the publication I. Dinstein et al., "On the Compression of Stereo Images: Preliminary Results", Signal Processing 17 (1989), s. 373-382.

CLAIMS

1. A method for performing motion estimation in video image compression, which method comprises the following stages:

5 the image block to be coded is determined on frame N,

 the search area corresponding to the location of the image block in question is determined on frame N-1,

10 the image block average values are determined in the location areas of the image blocks included in the search area in question by using a shift of predetermined size,

 the image blocks included in the search area
15 in question are arranged in a predetermined order on the basis of the image block average values of the image blocks in question.

 an alternative best matching with the image block to be coded is searched among the image blocks
20 of the search area in question, c h a r a c t e r - i s e d in that the method further comprises the following stages:

 the image blocks included in the search area are sorted by storing the image block average values
25 of the image blocks in question in the memory locations of the directory memory of an associative memory device in an ascending or descending order and by storing in the memory location of the output memory corresponding to each memory location of the directory
30 memory the location data of the image blocks whose image block average value corresponds to the value stored in the memory location of the directory memory in question,

 as a key word of the aforementioned associative
35 tive memory device, the image block average value of the image block to be coded is used,

the group of the image blocks to be processed is restricted on the basis of a mean error, and

the best match is searched among the image blocks included in the restricted group of images by
5 using the PDE method.

2. Method as defined in claim 1, characterised in that the method further comprises the stage:

as search area, a predetermined area of regular shape around the image block to be coded is used.
10

3. Method as defined in claim 1, characterised in that the method further comprises the following stages:

an area is defined that is comprised of an area of one or more objects moving fast between successive image frames,
15

and the said area is used as search area.

4. Method as defined in any one of claims 1 - 3, characterised in that the method further
20 comprises the following stage:

the possible location areas of the image blocks are determined by using a shift of one pixel, a half of a pixel or other fractional shift.

5. A system for performing motion estimation in video image compression, which system comprises:
25

means of determining (1) by means of which the image block average values are determined in the location areas of the image blocks included in the search area corresponding to the location of the image
30 block to be coded by using a predetermined shift on the image frame prior to the image frame including the image block to be coded in question,

means of sorting (2) by using which the image blocks are sorted on the basis of the image block average values of the image blocks in question, and
35

means of searching (3) by using which the variant best matching with the image block to be coded

is searched among the image blocks, characterized in that the system further comprises:

an associative memory device (2) by means of which the image blocks included in the search area are
5 sorted by storing the image block average values of the image blocks in question in the memory locations of the directory memory of the associative memory device in question (2) in an ascending or descending order and by storing in the memory location of the output
10 memory corresponding to each memory location of the directory memory the location data of the image blocks whose image block average value corresponds to the value stored in the memory location of the directory memory in question, and the image block average
15 value of the image block to be coded is used as a key word of the associative memory device (2).

means (3) for restricting the group of the image blocks to be coded on the basis of a mean error, and

20 means (3) for searching the best match among the image blocks included in the restricted group of images by using the PDE method.

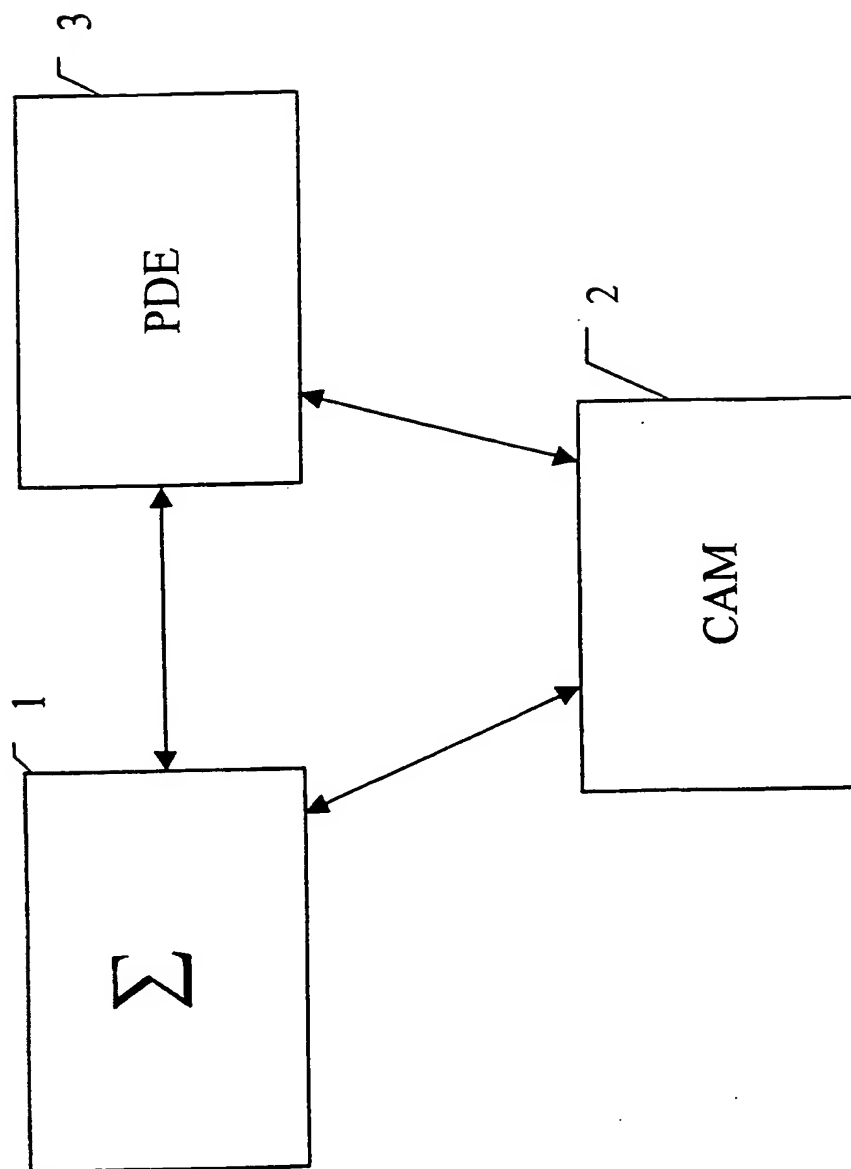


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/00586

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04N 7/26, H04N 7/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CHAUR-HEH HSIEH ET AL: Fast Search Algorithms for Vector Quantization of Images Using Multiple Triangle Inequalities and Wavelet Transform; IEEE Transactions on Image Processing, Vol. 9, No. 3. March 2000. See page 321, figure 8 --	1-5
A	US 5768629 A (ADRIAN WISE ET AL), 16 June 1998 (16.06.98), column 7 - column 12, abstract --	1-5
A	EP 0964583 A2 (TEXAS INSTRUMENTS INCORPORATED), 15 December 1999 (15.12.99), page 34, abstract -- -----	1-5

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT
Information on patent family members

03/10/00

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PCT/FI 00/00586

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US 6119213 A 12/09/00

EP 0964583 A2 15/12/99

WO 0012472 A 09/03/00

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